

## ATTACHMENT 5: WORK PLAN

*The work plan must be consistent with and support the budget and schedule. The level of detail must be sufficient for the work plan to function as the scope of work for the agreement and to allow reviewers to understand the level of effort of the work being performed as to further substantiate the cost estimates in the budget. If the applicant does not have an existing GWMP, then it should use this section to detail the process by which one will be created. The work plan should include, at a minimum, the following items:*

- *Scope of the proposed project including (as appropriate) maps of agency area and area of proposed tasks;*
- *Specific purpose, goals, and objectives of the proposed project related to improving groundwater management and implementing the GWMP and/or where applicable the IRWM Plan;*
- *Work items to be performed under each task of the proposed tasks (consistent with the budget and schedule);*
- *Present a sound strategy for evaluating progress and performance at each step of the proposed project.*
- *Project deliverables for assessing progress and accomplishments, which include quarterly progress and final reports.*
- *If access to private property is needed, provide assurance that access can be granted. For example, if wells will be constructed or sampled on private land, submit a letter or agreement that demonstrates that access for well construction and monitoring on the property has been obtained.*
- *Explain the plan for environmental compliance and permitting, including a discussion of the following items: a description of the plan, proposed efforts, and approach to environmental compliance, including addressing any CEQA obligations in connection with the proposal; a listing environmental related permits or entitlements that are needed for the project; and any other applicable permits that will be required. Briefly describe the process and schedule for securing each permit/approval. Discuss necessary local drilling permits and the submittal of Well Completion Reports to DWR. Describe the proposed process for securing each environmental permit and any other regulatory agency approval.*

## Project Scope and Objectives

The proposed project is described in detail in Attachment 4 Project Description, which includes a map showing the location of the Terranova Ranch near Helm, CA. The major objectives of the project are:

- 1) Quantify vadose zone impacts of capturing flood flows on agricultural lands;
- 2) Quantify hydrologic and selected water quality fluxes to groundwater; and,
- 3) Validate vadose zone model results against soil and groundwater data.

The project includes field evaluation of salts and nitrate fluxes into and out of the root zone, modeling of the hydrologic and chemical processes within the root zone, and modeling of salts and nitrate fluxes from the root zone to the groundwater table at about 200 feet below ground surface in the project area. Three new groundwater monitoring wells will be installed between Raisin City and the Terranova Ranch at Helm, CA to support the CASGEM monitoring effort, described in the Lower Kings River GWMP, and to provide data for use in the vadose zone modeling. The new wells will be sampled on a quarterly basis for water quality and water levels will be measured daily using pressure transducers and data loggers.

### TASK 1: ROOT ZONE CHARACTERIZATION

Soils in the root zone (0-1.5 m, or 0-5 feet) will be characterized chemically and physically at a number of field plots representing different cropping practices to quantify changes in soil chemistry, structure and hydrology in response to flood flow capture practices. The productive class 1 soils support excellent crop growth, are intensively agronomically managed and are likely to be most affected by climatic change. In addition, these soils represent typical high production areas and therefore are useful to examine for the effects of flood flow capture. The most critical environmental and agronomic factors will be examined that affect soil infiltration rates, the formation and dissolution of soil precipitates, nutrient cycling and loading, and organic matter content. Flood flow capture practices to promote recharge could greatly affect the soil chemistry and physics and impact soil productivity. For example, leaching of potassium could be a long-term issue affecting crop productivity. These field plots will be selected from a subset of fields at Terranova Ranch being utilized for the 5-year flood flow capture project for which contract negotiations are underway between DWR and KRCD.

#### Task 1.1 Agronomic Practices

For each plot in which soil data will be collected, detailed records of agronomic practices will be kept. These practices will include soil preparation, irrigation frequency and hydrologic loading, fertilization, fuel use, pesticide use and labor. These practices will be recorded for a period of an entire year to capture

seasonal management and the full annual cycle. This effort will support the 5-year flood flow capture project.

### Task 1.2 Instrumenting for shallow soil processes

Soil probes shall be installed to a depth of 1.5 meters to measure high frequency responses to irrigation/flood flow water applications. These probes will measure electrical conductivity (EC), temperature and moisture content. These probes will be calibrated with soil data collected during their installation. At these locations, pressure transducers will also be installed to help quantify surface hydrologic loading during flood flow or flood irrigation. The EC measurements are critical to understanding nitrate and salt movement and for providing data to test the hydrologic model.

### Task 1.3 Soil physics and chemistry

For these studies, soils will be cored before and following flood flow recharge implementation, following the cropping season to test for residual nitrogen and again before the next crop cycle following winter but before fertilizer is added for the next year's crop. Samples will be collected from the root zone at multiple depths through the profile (e.g., 0 - 15, 15 - 30, 30 - 60, 60 - 90, 90 - 150 cm) in fields representing a combination of different irrigation regimes (e.g., flood flow capture, over-irrigation, normal irrigation), different cropping practices (e.g., vineyards, alfalfa) and soils. Soils will be analyzed for a variety of constituents (e.g., moisture content, nitrate, EC, common anions and cations - Cl, SO<sub>4</sub>, K, Ca, Mg). If hydraulic conductivity data are not available as a function of saturation, selected samples to represent the most common soil types in the vadose zone will be tested in the laboratory to obtain this parameter.

### Task 1.4 Supplemental Field/Laboratory Studies and CIG project data mining

It is currently anticipated that investigations under this task will be conducted as field studies. However, laboratory studies may be needed to supplement the data if field conditions for high hydrologic loading under flood flow conditions cannot be achieved in the field during this investigation<sup>1</sup>. We propose to utilize two approaches to augment field data collection for this project. First, a rich data set obtained from a currently funded NRCS Conservation Innovation Grant (CIG) investigation will be mined for relevant information<sup>2</sup>. For check studies under different hydrologic loading regimes, we have soil probe data (e.g., EC, temperature, moisture content), hydrologic loading rates, irrigation practices, and soil cores up to 20 meters. Intact soil cores also exist for the CIG data. These data and field samples should provide supplemental data in support of this study. Additionally, laboratory studies using field cores and

soil samples can be collected to simulate soil chemical responses to high hydrologic loading rates as well as determining hydraulic conductivities.

### Task 1.5 Anticipated Analyses and Coupling with Vadose Zone Models

Two vadose zone models are currently planned: 1) a model representing the root zone, and 1-D models representing the subsurface from below the root zone to the groundwater table, as discussed in Task 4. High resolution data from soil cores to 20m in depth will be obtained. Data from this task will be used to calibrate hydraulic and adsorptive characteristics of these shallow soils, provide boundary data with regard to management practices as cultural inputs to the vadose zone model, integrate root zone constituent cycling and transport into and through the root zone component, and provide the fluxes to the deep vadose zone model.

Additional analyses are planned including the determination of statistical differences between field plots as represented by varying cultural practices, hydrologic management and soil characteristics. Short and long-term temporal effects with regard to salts and hydrology will be characterized using the high frequency instrument data for moisture content and grain size and the importance of those changes to longer-term effects and soil processes. Finally, mass balances will be conducted on the shallow vadose zone to understand soil constituent inputs, outputs and cycling. The root zone model will evaluate fluxes of nitrate, salts, and other constituents of agronomic interest (e.g., potassium). The salts and nitrate fluxes out of the root zone will be used as input to the deep vadose model discussed in Task 4.

#### Deliverables

- Experimental design for field plot studies integrated with DWR Flood Flow Capture Project
- Model integration, calibration and validation for root zone
- Memo – Chemical and physical changes in the root zone of agronomic fields being used for groundwater recharge

### TASK 2: UPPER VADOSE ZONE CHARACTERIZATION (0 – 15 M)

Soil cores will be taken before and after implementing the different hydrologic regimes representing flood flows and typical irrigation practices. These cores will be taken with the GeoProbe which can sample intact cores to a depth of about 20 meters. These cores will then be analyzed for EC, nitrate

<sup>1</sup> Flood flow capture BMPs will require flood flow conditions in the Kings River.

<sup>2</sup> AGREEMENT NO.68-9104-0-128; Demonstrating Groundwater Recharge with Storm Flood Flows on Agricultural Lands using Best Management Practices to mitigate groundwater overdraft

and other constituents described in Task 1.3 as necessary. These cores will also be used to characterize soil lithology in the upper 20 meters and enable sampling of different soils (e.g., sands, silty sands, sandy silts, silts) to determine hydraulic conductivity and adsorption coefficients in the laboratory. These data will be used in the development of the model and for calibrating the model. Data taken from before and after the hydrologic treatments will be used to validate the model's response.

### Deliverables

- Experimental design for upper vadose zone characterization
- Validation data for upper vadose zone modeling
- Memo – Chemical and physical changes in the upper vadose zone of agronomic fields being used for groundwater recharge

### TASK 3: GROUNDWATER WELL INSTALLATION AND SAMPLING:

This task is composed of four major subtasks: (1) Site selection and analysis; (2) Well construction and development; (3) Telemetry and installation and setup; and 4) Sampling. The purpose of this task is to increase the capability to monitor a known area of severe groundwater overdraft, evaluate changes in groundwater storage that result from Kings River flood operations, and monitor direction and rate of groundwater flow in the region. The groundwater levels in the region have remained remarkably static during the last decade of monitoring, showing only the expected fluctuations in levels that would result from two flood events. It is surprising that a stronger recovery has not taken place as there is a substantial gradient in the depth to groundwater extending southwest from the Fresno Wastewater Treatment facility to the study area. The placement of the dedicated monitoring wells should help in determining the reasons for the observed gradients. Secondary benefits include evaluation of the implementation of the McMullin On-Farm Flood Capture and Recharge Project, increased knowledge of the local geologic conditions, and capability to monitor groundwater quality.

#### **Task 3.1 Site Selection**

Based on current knowledge of the region developed through previous DWR-funded studies and current KRCD groundwater monitoring activities, the area where this grant will be implemented is located directly above the deepest portion of the groundwater depression within the Kings River Basin. The local landowner, Terranova Ranch, has agreed to provide access to its property for the installation of up to three dedicated groundwater monitoring wells. In addition, the ranch owners have agreed to potentially assist in getting the cooperation of surrounding landowners to identify additional well sites should it be decided that a wider distribution of the new wells is warranted. Terranova is a forward thinking agricultural operation, dedicated to both innovative approaches to crop production and resource management.

The criteria for well site selection are discussed below:

1. Well sites need to be spatially located to appropriately monitor groundwater movement and recovery rates from Kings River flood releases.
2. Well sites need to be sufficiently located away from active production wells to avoid interference from the cones of depression.
3. Well sites need to be located away from nitrate sources besides fertilizer that might impair identification of effects of the recharge flood flow releases.
4. Well sites cannot interfere with on-going cultural practices or planned artificial recharge operations when flood waters are available (McMullin On-Farm Flood Capture and Recharge Project).

Appropriate level of CEQA review of the proposed sites will be conducted. The lands where the wells would be located are already considered to be disturbed, so a simple review process is all that is required. A previous cultural impact survey indicated that some activity may have occurred within the Fresno Slough/James Bypass, but it is not anticipated that any other impacts will be seen. The normal precautions will be taken should any artifacts be encountered. Wildlife habitat disturbance should be minimal, and would only occur during drilling operations. KRCD Environmental staff will be included in the Site survey process. Each site will be photo surveyed prior to any drilling work beginning to confirm that no wildlife habitat of concern is present.

### Task 3.2 Well Construction and Development

The design for the monitoring wells will include: well depth (expected to 300 to 350 ft deep to allow for dry periods), vault and protective posts for the surface completion, and casing and screen requirements. The design will be specified in the bid solicitation package for the drillers. The drilling specifications will include preferred driller methods, sampling requirements, and clean-up and water and waste disposal practices. It is anticipated that many of the specifications used during the Aquifer Characterization and Performance Management within Kings River Conservation District Groundwater Management Area C (DWR Grant Agreement 4600002460) will apply to this project as well. The only significant change to these specifications will be the addition of the necessary equipment for the remote telemetry portion of the project, discussed in Task 3.3. Once the specifications are published and a contractor is selected via a sealed bid process, drilling and installation of the monitoring wells will be scheduled with the winning contractor so as to minimize any negative interference with farming operations at Terranova. Prior to actual field work, well permits will be obtained from Kings County. After surveying of the well, a report of the well will be provided to CASGEM, since these wells will also be used in that program. The wells will be logged by a KRCD Board member, who is a Registered Geologist/Certified Hydrogeologist. Soil samples will be obtained using split-spoon samplers or cores at 10-ft intervals in the deeper vadose zone (5 to 200 ft) from these groundwater wells to determine the lithology of the vadose zone. Soil samples will be tested in a laboratory to measure cation exchange capacity (CEC) and hydraulic conductivity. These data will be used in the development of the vadose zone model from 5 feet below the ground surface to the groundwater table. Following



installation of the wells, they will be developed by the drilling contractor or another contractor using surging and pumping to insure that high quality water samples with low turbidity can be obtained from the wells.

GPS surveying (location coordinates, land surface elevation, reference point within the well using RTK equipment) of the installation sites will be done after the wells are installed. Benchmarks will be installed for use within the Kings Basin subsidence monitoring grid, with elevation readings updated approximately every 5 years. Well construction data will be uploaded into the CASGEM system once the well reports are submitted by the drilling contractor.

### Task 3.2 Telemetry system installation

A telemetry system (secure wire chases, antenna mast) will be installed in each well. The contractor specifications will be reviewed and approved by the KRCD Chief Engineer prior to being placed out to bid. Sufficient lead time between the drilling of the well and subsequent development and the data logger installation shall take place to allow for the groundwater levels to stabilize. Pressure transducers and data loggers will be installed in the three new wells to measure water levels on a daily basis. Internet access to the reported data will be handled by the third party that is providing the equipment to the KRCD. The water level data will be used in the vadose zone modeling, described in Task 4. Water level data provided by the telemetry system from the new groundwater wells will be used to determine how long it takes for recharge under different hydrologic loading rates to reach the water table. The results will be used to validate the model responses.

### Task 3.3 Groundwater Sampling

Groundwater samples will be collected and analyzed for nitrate and EC. Field parameters will also be measured including temperature and pH. These data will be used to document real-time changes in water quality in response to area and regional management.

### Deliverables

- Water quality data (e.g. nitrate, EC) and field parameters (e.g. temperature, pH)
- Hydraulic head data to quantify changes in groundwater in response
- Report on well installation and development with tabulated design parameters

### TASK 4: DEEP UNSATURATED ZONE MODELING

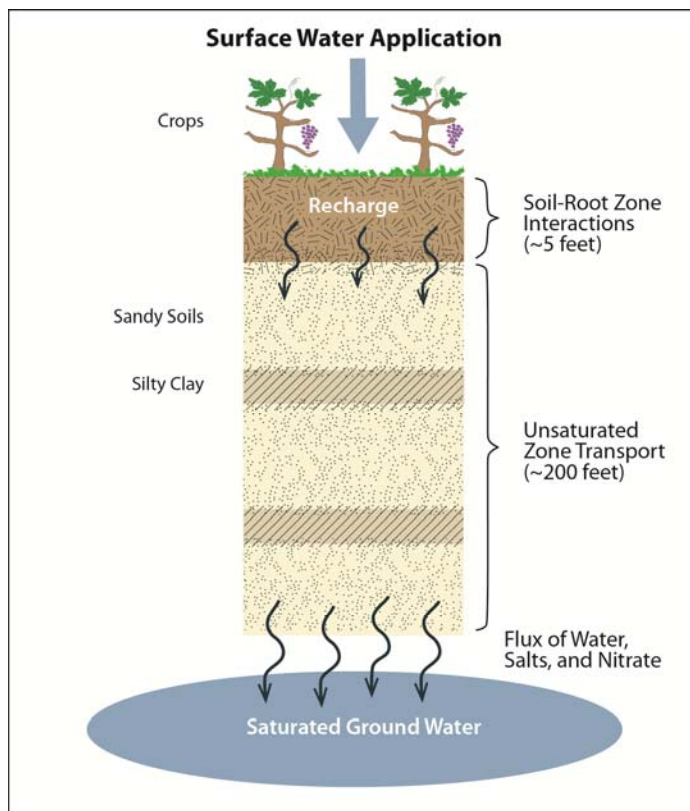
The effect of recharge on nitrate and salts present in the soils underlying the Terranova Recharge Project Site will be evaluated using 1-D unsaturated zone models. The objective is to follow the movement of the nitrate and salts from the base of the root zone considered to be a depth of 5 feet to the water table

at a depth of about 200 feet (Figure 1). Interactions in the root zone, especially nitrogen cycling, will be computed separately (Task 1.5), and will form the upper boundary of the modeling for the unsaturated zone. The model will be used to evaluate four scenarios: flood irrigation, over-irrigation, normal irrigation, and dry conditions for a range of typical soil conditions in a Monte Carlo framework for vineyards and alfalfa. The intent is to quantify the fluxes of nitrate and salt that may reach the water table under different recharge scenarios, the time frame of the transport, and whether the sequence or duration of the scenarios influences the transport of nitrate in soil. Two approaches will be tested: a 1-D analytical model and a 1-D numerical model of unsaturated zone groundwater flow and solute transport. The advantage of the analytical model is that it requires less data and has a short run time, but it can be configured only for relatively uniform soil parameters. The benefit of using a numerical model is that it can handle multiple soil layers, although it is more computationally complex to implement and calibrate. The goal of the model selection would be to identify the most appropriate model for the conditions prevalent in the study area. Both models would use the flux out of the root zone as input to the model simulations.

We propose using both analytical and numerical codes to simulate the one-dimensional flow of water and fluxes of salts and nitrates from the bottom of the root zone to the top of the groundwater table. The analytical solution of the advection-dispersion equation for solute transport (Cleary and Ungs, 1978) assumes all of the physical parameters are constant and single-valued over the time and spatial domain of interest. However, the initial distribution of nitrates and salts can vary with depth and the nitrate and salt concentration entering the soil column may vary arbitrarily with time, but

the water flux rate is assumed to remain constant. The numerical code, HYDRUS-1D (Šimůnek et al, 2005), will be used to determine if the simpler analytical solutions can correctly simulate the flood flow and irrigation problems of interest. The analytical solutions are substantially faster to run, which can be an important consideration during calibration and when Monte Carlo simulations are to be made.

HYDRUS-1D was developed jointly by Rien van Genuchten at the U.S. Salinity Laboratory of the USDA, Agricultural Research Service and by Jirka Šimůnek from the Dep. of Environmental Sciences at the University of California, Riverside. The program uses linear, Galerkin, finite elements to numerically





solve the Richards equation for unsaturated, partially saturated, or fully saturated homogeneous layered media and advection-dispersion equations for solute transport. The unsaturated soil properties can be described using Brooks-Corey and van Genuchten type functions of soil water retention versus hydraulic conductivity. The code incorporates hysteresis by assuming that drying scanning curves are scaled from the main drying curve and wetting scanning curves from the main wetting curve. The water flow model considers prescribed head and flux boundaries, boundaries controlled by atmospheric conditions, as well as free drainage boundary conditions. Physical non-equilibrium solute transport can be accounted for by assuming a two-region, dual-porosity type formulation that partitions the liquid phase into mobile and immobile regions. Thus, HYDRUS-1D provides a more general solution, and will be used if it is demonstrated that the analytical solutions are not adequate to match the subsurface heterogeneities present at the study site.

The soils information from the three new groundwater wells planned for installation by KRCD, new 15 m soil cores, and previous soil cores to a depth of 100 feet from nearby areas such as the McMullin Recharge Feasibility Study will be used to determine how many soil layers are needed for simulating the vadose zone from the base of the root zone to the groundwater table. For each layer used to represent the soil, the following data will be obtained: soil type, porosity, initial moisture conditions, hydraulic conductivity as a function of saturation, and parameters to describe moisture retention as a function of saturation. Measurements at intervals throughout the soil column are needed for nitrate, salts and EC.

### Deliverables

- Memo on input data and summary of deep vadose modeling used for recharge simulations
- Memo on comparison of salt and nitrate fluxes to groundwater table under different recharge conditions
- Memo on Model simulation results on effects of recharge over 50 years using flood flow and other irrigation methods
- Calibrated vadose zone model

### TASK 5: OUTREACH

The proposed project will be coordinated with several existing projects (See Table 1 in Attachment 4) including the DWR Flood Flow Capture project that is currently being implemented on the Terranova Ranch, the NRCS CIG grant, KRCD's Remote Telemetry Project (RMT), and the network of wells used in the CASGEM program that KRCD provides reports on for the Kings River Basin. The new well data obtained from Task 3 will be provided in the Annual Groundwater Report published by KRCD. Water quality data for groundwater will be provided to the proposed project and for use in the CASGEM program and to the RWQ to comply with the pending General Order for Waste Discharge for the Tulare Lake Basin. Information from the new wells will be available for use in the RMT project and in the



GWMP. Results of the field and modeling studies related to nitrate and salt movement in the vadose zone will be presented at local or regional workshops on similar issues.

#### TASK 6: ADMINISTRATION

The proposed project will be administered by KRCD. Administration will include, but is not limited to, communication with CDWR, Labor Compliance, preparation and delivery of quarterly invoices and reports, and final reporting and contract close out.

#### References

Šimůnek, Jirka, Martinus Theodorus van Genuchten, and Miroslav Šejna. 2005. The HYDRUS-1D Software Package for Simulating the One-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media, Version 3.0. Department of Environmental Sciences, University of California, Riverside, Riverside, California, April 2005.

Cleary, R. W. and M. J. Unga. 1978. Groundwater Pollution and Hydrology, Mathematical Models and Computer Programs. Water Resources Program, Report No. 78-WR-1, Princeton University, Princeton, N.J.